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CHARACTERISTICS OF SUBMARINE CABLE, TYPE 216.(U)
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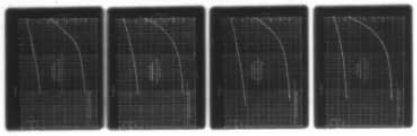

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CHARACTERISTICS OF SUBMARINE CABLE, TYPE 216.

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TECHNICAL MEMORANDUM

CHARACTERISTICS OF SUBMARINE CABLE, TYPE 216

by G. M. Wenz

INTRODUCTION

Because information on the characteristics of submarine cable, Type 216, was not readily available, impedance measurements have been made and characteristics computed. This memorandum has been prepared for future reference and for use by those who have expressed interest in the results.

THE MEASUREMENTS

Open circuit and short circuit impedances were measured at selected frequencies from 62.5 cps to 20 kc. A Z-angle meter, Technology Instrument Corporation, Type 310-A, was used to find the magnitude and angle of the impedance. The cable sample was a half-mile (nautical) reel (3,035 feet) procured under Navy Contract NObsr-52318 from Anaconda Wire & Cable Company.

Submarine cable, Type 216, is a sixteen-conductor armored cable with four conductors inside an inner shield arranged as shown in Figure 1. With the cable on the reel, measurements were made of adjacent and of opposite pairs, both inside and outside the inner shield. Unused pairs were open-circuited. The test set-up is shown in Figure 2, and the specific pairs used are stated in the tabulation of results.

THE COMPUTATIONS

Cable characteristics were computed using the following relations.[1]

Measured:

open-circuited impedance $Z_{oc} = |Z_{oc}| \angle \theta_{oc}$

short-circuited impedance $Z_{sc} = |Z_{sc}| \angle \theta_{sc}$

Characteristic impedance:

$$Z_o = (Z_{oc} \cdot Z_{sc})^{\frac{1}{2}} = R_o + j X_o$$

R_o = characteristic resistance, X_o = characteristic reactance

Propagation constant:

$$\gamma = \frac{\tanh^{-1} (Z_{sc}/Z_{oc})^{\frac{1}{2}}}{\ell} = \alpha + j\beta$$

ℓ = 0.5 nautical mile

α = attenuation constant

β = wavelength constant

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1. W. L. Everett, "Communication on Engineering" (McGraw Hill, 2nd Ed. 1937) p. 168.

Attenuation constant: in db/mi, $\alpha' = 8.686\ \alpha$

Impedance per mile:

$$Z = Z_o\ \gamma = R + j2\pi fL$$

R = resistance per nautical mile, L = inductance per nautical mile, and f = frequency

Admittance per mile:

$$Y = \frac{\gamma}{Z_o} = G + j2\pi fC$$

G = conductance per nautical mile,

C = capacitance per nautical mile.

The angle of the admittance, Y, is very close to ninety degrees at all frequencies considered. The conductance, G, equal to the magnitude of Y times the cosine of this angle, is not only very small but also changes rapidly with the small angle changes in the neighborhood of ninety degrees. The precision of measurement is not sufficient to determine these small changes accurately and values of G were not obtained. Some values of L, which are dependent upon the sine of an angle one degree or less, are also omitted.

THE RESULTS

The results are tabulated on the following page. The characteristic impedance and propagation constants are shown in graphical form also. It should be remembered that these measurements refer to cable on a reel, in air, with ambient temperatures fifty degrees F., to seventy-five degrees F., and near sea level atmospheric pressure.

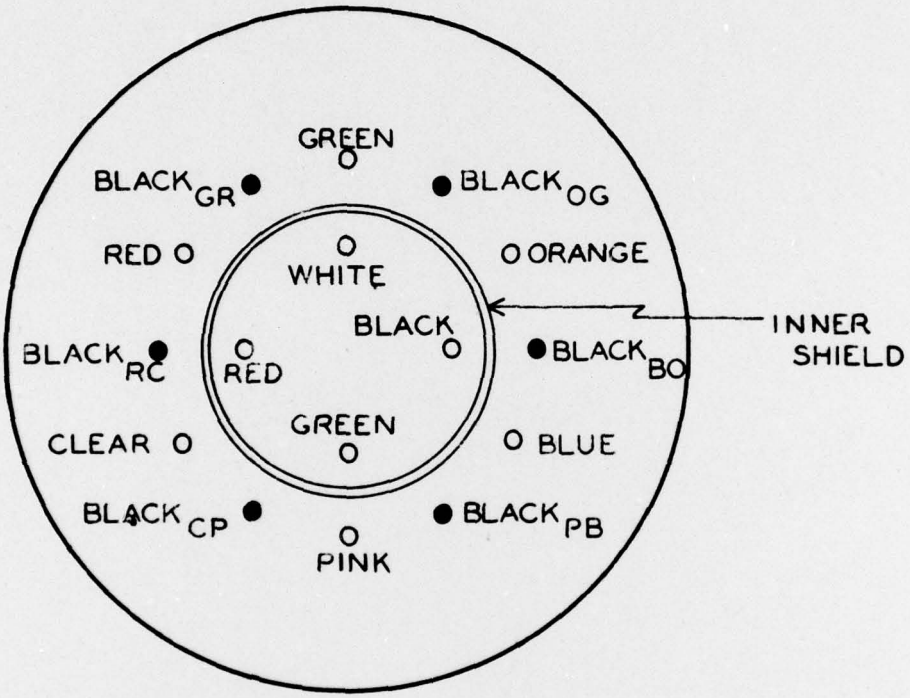
CHARACTERISTICS OF TYPE 216 SUBMARINE CABLE

Adjacent Pair Outside Shield (Orange and Black$_{og}$):

FREQ. CPS	Z_{oc}		Z_{sc}		Z_o		γ		α'	Z		C
	Z_{oc} ohms	θ_{oc} Deg.	Z_{sc} ohms	θ_{sc} Deg.	R_o ohms	$-X_o$ ohms	α Nepers/mi.	β Radians/mi.	db/mi.	R ohms/mi.	L mh/mi.	µfd/mi.
62.5	47500	-90.0°	13.5	0.2°	566	566	0.0237	0.0238	0.206	26.9	---	.107
125	24000	-90.0	13.5	1.0	406	399	.0332	.0338	.288	27.0	---	.106
250	12000	-90.0	13.6	3.0	293	278	.0462	.0487	.401	27.1	.903	.106
500	5990	-89.9	13.8	9.5	220	186	.0620	.0731	.539	27.2	1.45	.106
1 kc	3000	-89.8	14.3	19.5	169	119	.0794	.113	.690	26.9	1.53	.105
1.5 kc	2025	-90.0	15.2	27.0	150	91.7	.0907	.147	.788	27.0	1.45	.104
2 kc	1530	-90.0	16.6	34.0	141	74.8	.0989	.184	.859	27.9	1.43	.104
5 kc	623	-89.7	26.8	57.5	124	35.8	.113	.393	.979	28.1	1.43	.101
10 kc	310	-89.2	48.4	69.5	121	20.8	.126	.660	1.10	29.0	1.23	.0874
20 kc	140	-90.0	99.5	72.5	117	17.2	.159	1.40	1.38	42.7	1.28	.0949
Adjacent Pair Inside Shield (Average of Black and Green and Black and White):												
125	23900	-90.0	13.8	2.0	413	399	.0334	.0346	.290	27.6	---	.106
250	12000	-90.0	13.8	4.2	298	277	.0461	.0497	.401	27.6	1.35	.107
500	5950	-90.0	14.2	9.0	221	189	.0634	.0743	.550	28.0	1.42	.107
1 kc	3000	-90.0	14.8	18.6	171	123	.0817	.114	.710	28.0	1.51	.106
1.5 kc	2035	-90.0	15.8	25.8	152	95.3	.0932	.149	.809	28.4	1.47	.104
2 kc	1530	-90.0	17.2	31.8	142	78.9	.102	.185	.889	29.1	1.44	.104
5 kc	635	-90.0	26.5	52.0	123	42.2	.128	.383	1.12	31.9	1.32	.0992
10 kc	309	-89.9	44.2	63.6	114	26.7	.136	.655	1.18	32.9	1.13	.0911
20 kc	134	-88.7	86.6	70.0	106	17.6	.182	1.36	1.58	43.1	1.12	.101
Opposite Pair Inside Shield (Black and Red):												
125	25800	-90.0	13.7	2.0	428	413	.0320	.0332	.278	27.4	---	.0988
250	13000	-90.0	13.8	6.0	315	284	.0436	.0484	.378	27.4	1.84	.0980
500	6500	-90.0	14.1	11.0	237	188	.0592	.0719	.514	27.6	1.87	.0980
1 kc	3300	-90.0	14.9	22.0	184	124	.0749	.111	.651	27.6	1.78	.0965
1.5 kc	2250	-90.0	16.5	29.0	166	97.8	.0865	.148	.751	28.8	1.70	.0943
2 kc	1690	-90.0	18.2	35.0	156	81.0	.0951	.184	.826	29.7	1.67	.0940
5 kc	680	-90.0	29.3	52.0	134	46.0	.130	.389	1.13	35.3	1.47	.0926
10 kc	330	-89.5	47.4	62.5	122	29.2	.162	.710	1.40	40.3	1.30	.0926
20 kc	148	-87.5	91.2	71.0	115	16.8	.184	1.33	1.60	43.4	1.19	.0917
Opposite Pair Outside Shield (Orange and Clear):												
62.5	52500	-90.0	13.8	2.0	612	591	.0225	.0233	.195	27.6	2.45	.0969
125	27000	-90.0	13.8	5.0	450	412	.0305	.0333	.265	27.5	3.06	.0942
250	13700	-90.0	13.8	10.0	334	280	.0462	.0484	.401	29.0	2.04	.0976
500	6800	-89.9	14.5	18.0	254	184	.0543	.0744	.472	27.5	2.8	.0934
1 kc	3600	-89.9	16.7	31.0	214	120	.0670	.112	.582	27.7	2.51	.0846
1.5 kc	2420	-89.9	19.7	40.0	198	91.9	.0760	.162	.660	30.0	2.65	.0869
2 kc	1870	-88.2	23.0	46.0	193	75.3	.0855	.204	.743	35.9	2.76	.0850
5 kc	750	-90.0	42.0	60.0	171	45.9	.116	.450	1.01	40.6	2.28	.0834
10 kc	370	-90.0	71.8	67.0	157	44.9	.148	.811	1.29	59.8	1.92	.0801
20 kc	167	-90.0	145	67.5	153	30.3	.198	1.50	1.72	75.3	1.77	.0771

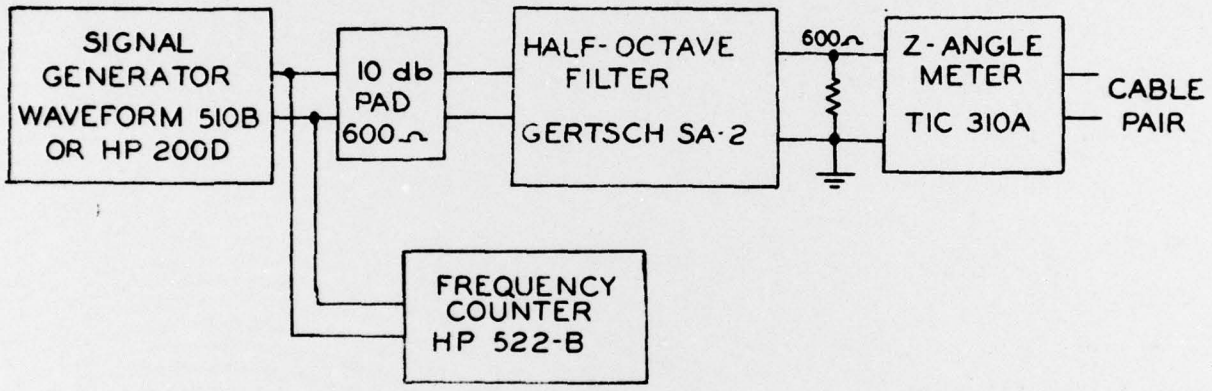
See Figure 1 for arrangement of conductors.

See Section III for definition of symbols at head of table.



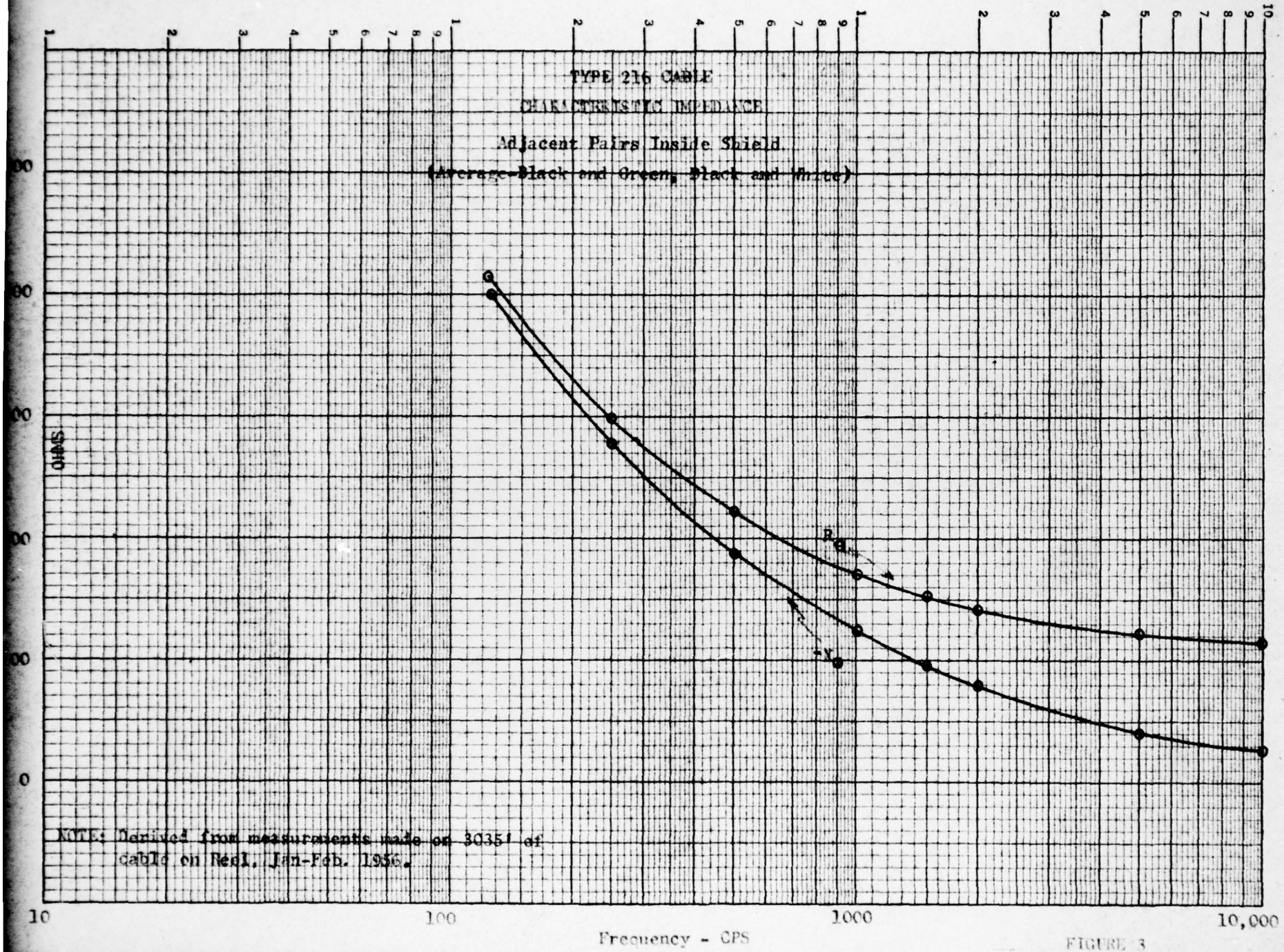
ARRANGEMENT OF CONDUCTORS
SUBMARINE CABLE TYPE 216

FIGURE 1



MEASUREMENT SYSTEM

FIGURE 2



NOTE: Derived from measurements made on 3035' of cable on Reel, Jan-Feb. 1956.

FIGURE 3

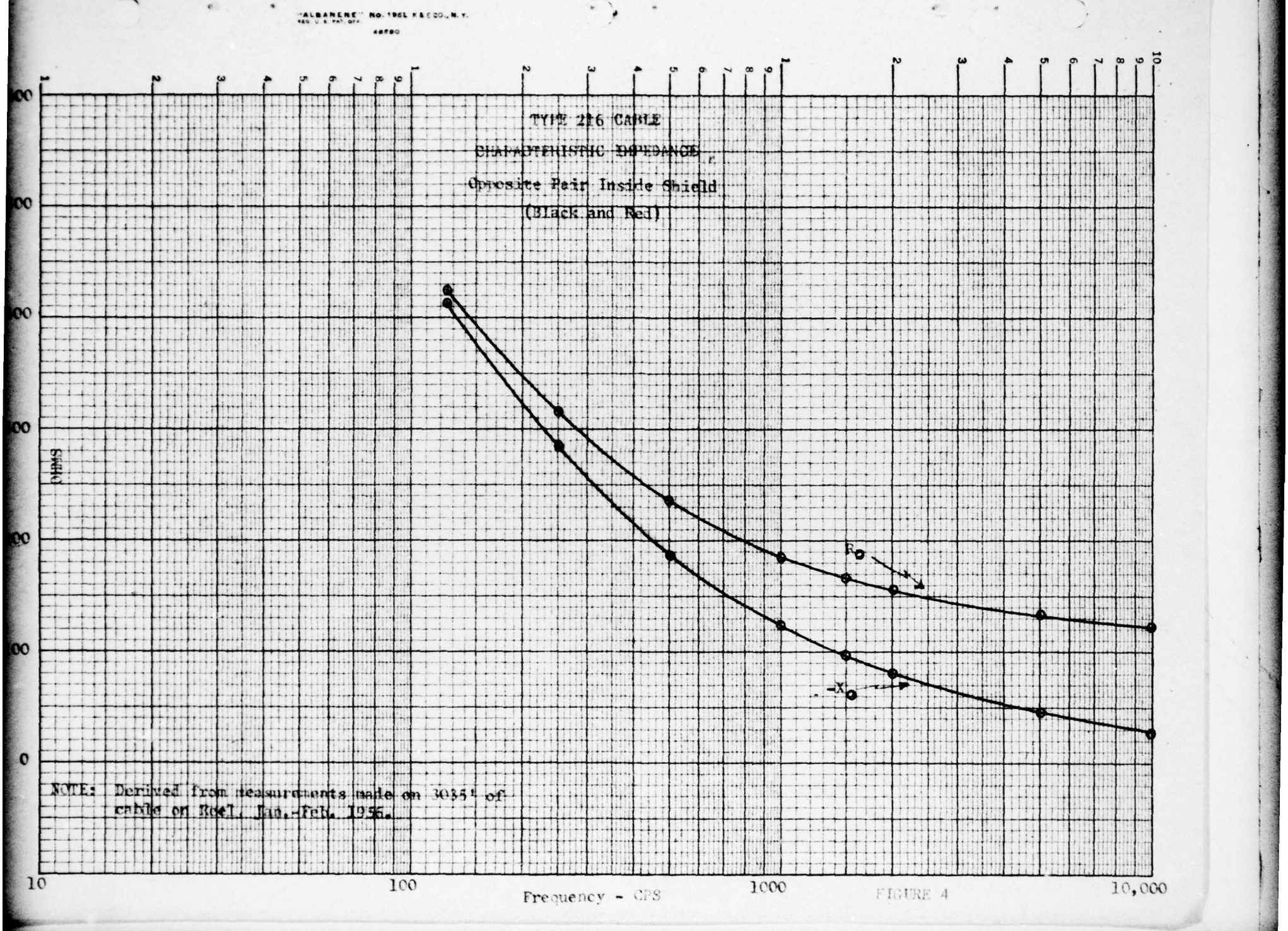

TYPE 216 CABLE
CHARACTERISTIC IMPEDANCE
Opposite Pair Inside Shield
(Black and Red)
OHMS
R_o
$-X_o$
NOTE: Derived from measurements made on 3035' of cable on Reel, Jan.-Feb. 1956.
10
100
1000
10,000
Frequency - CPS

FIGURE 4

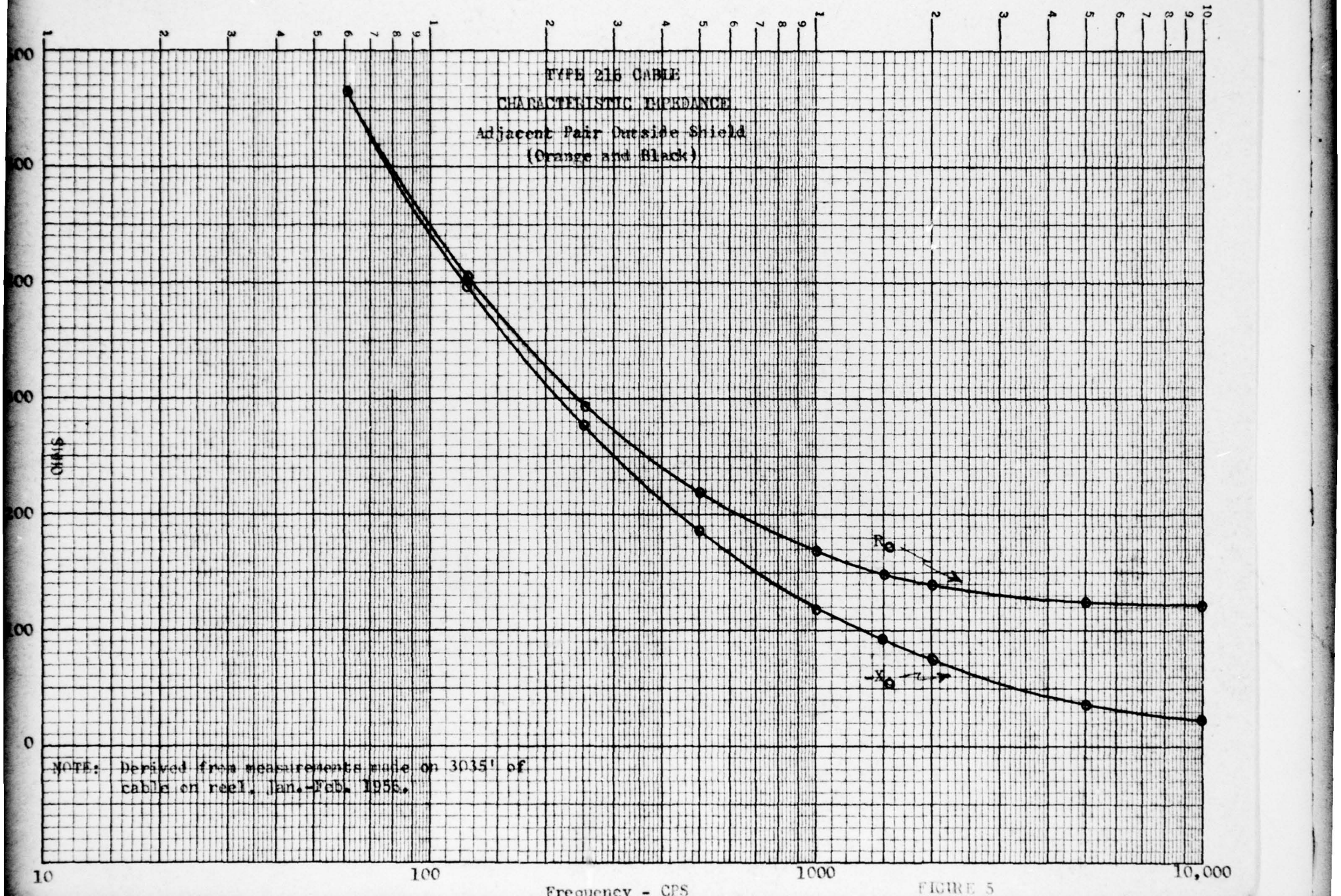

TYPE 216 CABLE
CHARACTERISTIC IMPEDANCE
Adjacent Pair Outside Shield
(Orange and Black)
R_o
$-X_o$
NOTE: Derived from measurements made on 3035' of cable on reel, Jan.-Feb. 1956.
10
100
1000
10,000
Frequency - CPS

FIGURE 5

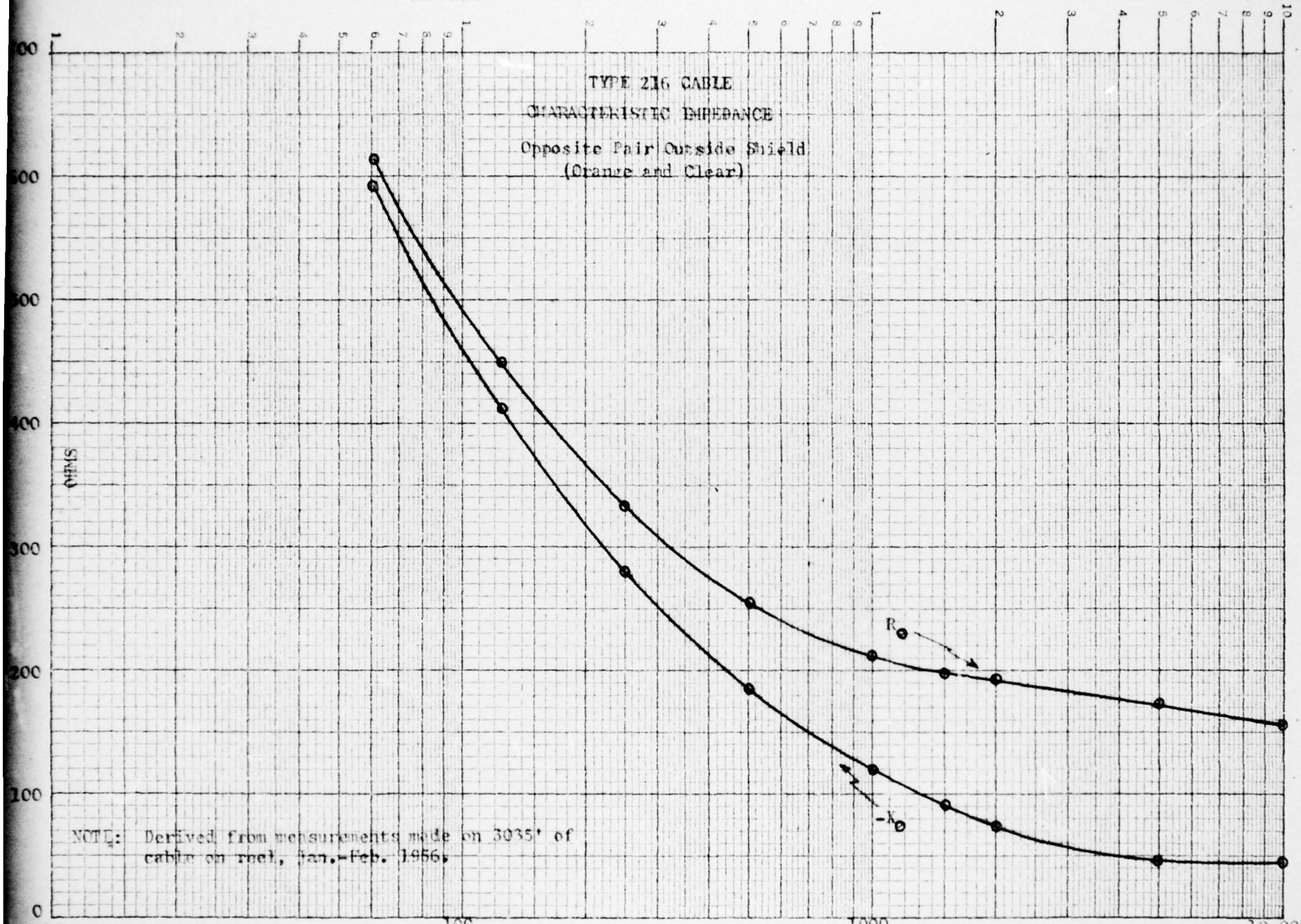

TYPE 216 CABLE
CHARACTERISTIC IMPEDANCE
Opposite Pair Outside Shield
(Orange and Clear)
OHMS
0
100
200
300
400
500
600
700
10
100
1000
10,000
Frequency - CPS
R_o
$-X_o$
NOTE: Derived from measurements made on 3035' of cable on reel, Jan.-Feb. 1956.

FIGURE 6

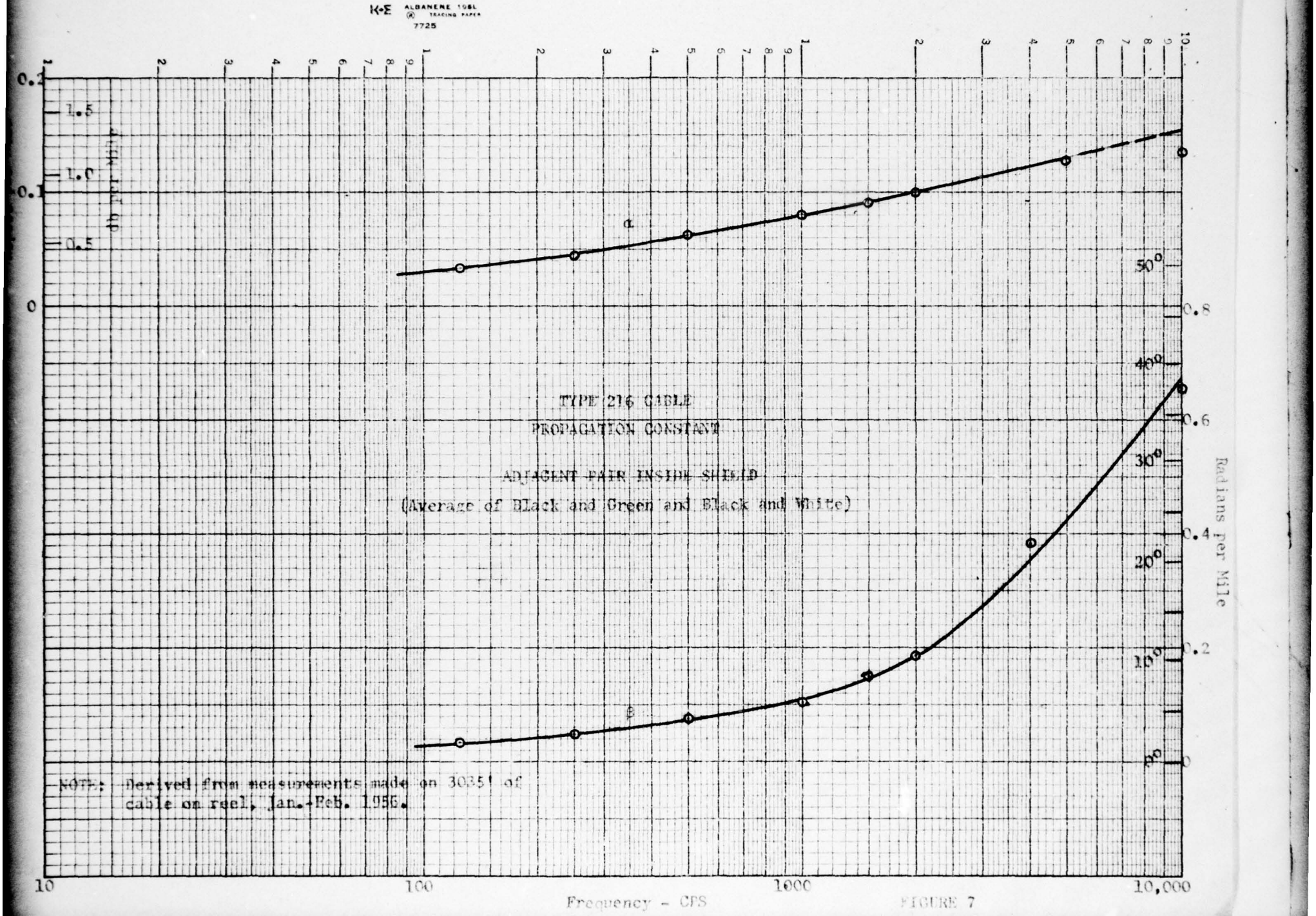

K+E ALBANENE 1961
TRACING PAPER
7725
0.2
0.1
0
1.5
1.0
0.5
db per Mile
α
β
50°
40°
30°
20°
10°
0°
0.8
0.6
0.4
0.2
0
Radians per Mile
TYPE 216 CABLE
PROPAGATION CONSTANT
ADJACENT PAIR INSIDE SHIELD
(Average of Black and Green and Black and White)
NOTE: Derived from measurements made on 3035' of cable on reel, Jan.-Feb. 1956.
10
100
1000
10,000
Frequency - CPS

FIGURE 7

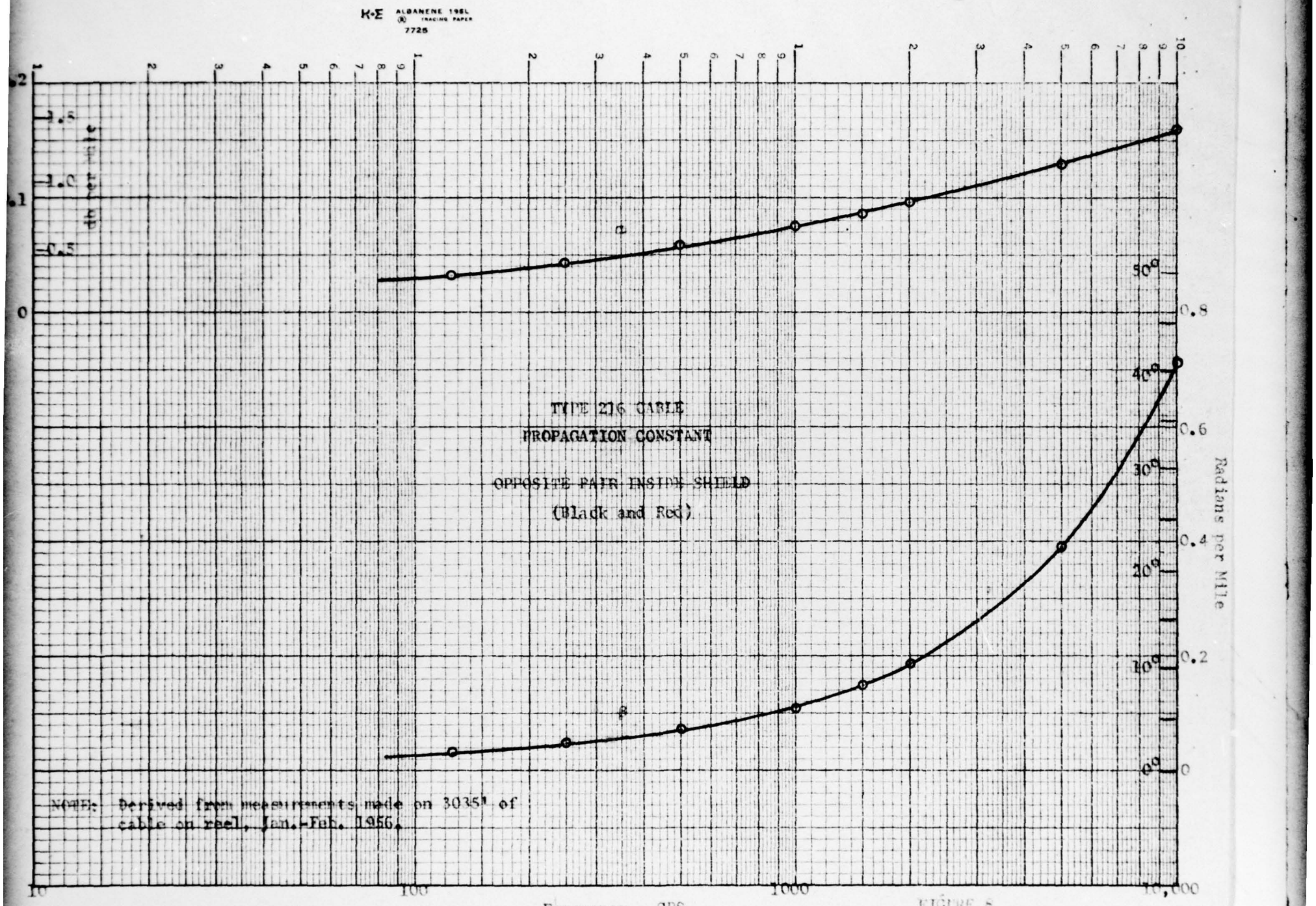

TYPE 216 CABLE
PROPAGATION CONSTANT
OPPOSITE PAIR INSIDE SHIELD
(Black and Red)
α
β
NOTE: Derived from measurements made on 3035' of cable on reel, Jan.-Feb. 1956.
Frequency - CPS
Radians per Mile
10
100
1000
10,000
0
0.2
0.4
0.6
0.8
50°
40°
30°
20°
10°
0°

FIGURE 8

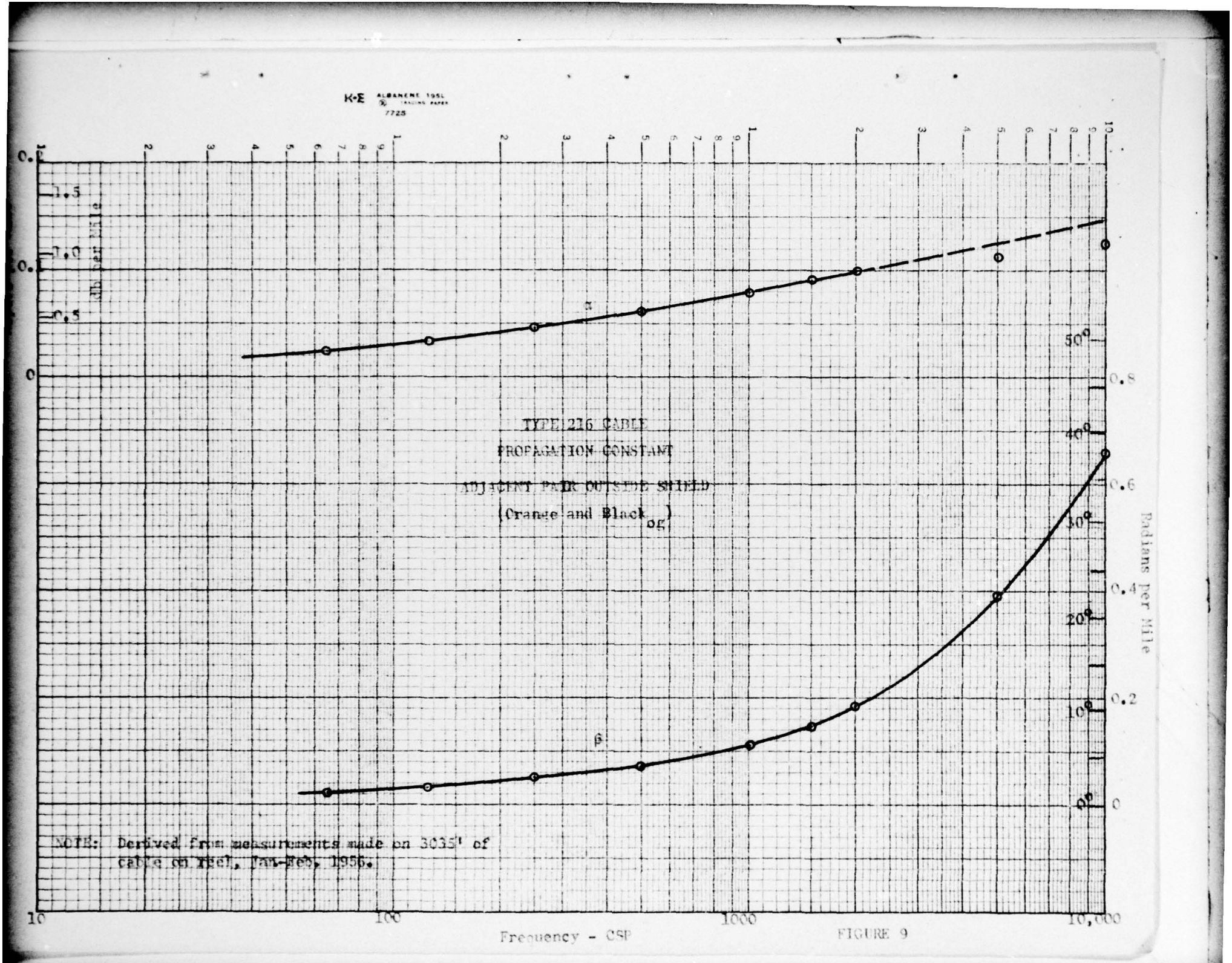

TYPE 226 CABLE
PROPAGATION CONSTANT
ADJACENT PAIR OUTSIDE SHIELD
(Orange and Black pg)
α
β
NOTE: Derived from measurements made on 3035' of cable on reel, Jan-Feb, 1956.
Decibels per Mile
Radians per Mile
Frequency - CSP
1.5
1.0
0.5
0.8
0.6
0.4
0.2
0
50°
40°
30°
20°
10°
0°
10
100
1000
10,000

FIGURE 9

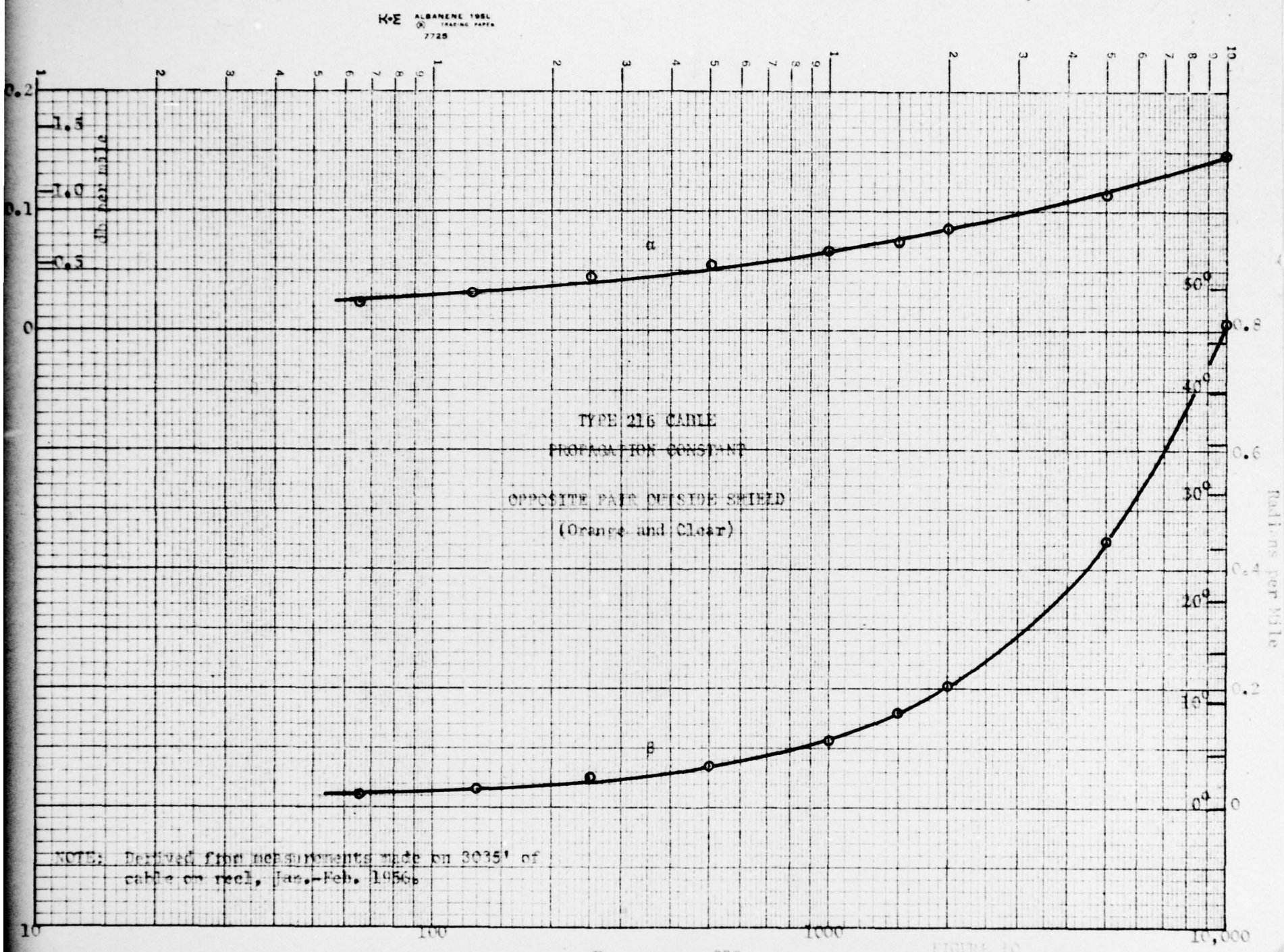

K&E ALBANENE 195L
7725
0.2
0.1
0
1.5
1.0
0.5
db per mile
α
β
50°
40°
30°
20°
10°
0°
0.8
0.6
0.4
0.2
0
Radians per Mile
TYPE 216 CABLE
PROPAGATION CONSTANT
OPPOSITE PAIR INSIDE SHIELD
(Orange and Clear)
NOTE: Derived from measurements made on 3035' of cable on reel, Jan.-Feb. 1956.
10
100
1000
10,000
Frequency - CPS

FIGURE 10